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Research Article

Anticipating an Easier Day: Effects of Adult Day Services on Daily Cortisol and Stress

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Abstract

Purpose of the Study: Family caregivers experience high levels of stress that place them at risk for poor health outcomes. We explore whether an intervention which lowers caregivers' daily exposure to stressors, adult day services (ADS), leads to improved regulation of the stress hormone, cortisol, which has implications for health and well-being.
Design and Methods: Participants (N = 158) were family caregivers of individuals with dementia (IWD) who were using ADS. Eligibility included: the IWD had a dementia diagnosis, IWD used ADS at least twice a week, and IWD and caregiver lived in the same household. A within-subject treatment design was used to compare caregivers' diurnal cortisol responses on days they received the intervention (ADS use by the IWD) and days they did not. Participants completed daily interviews over eight consecutive days and provided five saliva samples on each of those days. Primary outcomes were salivary cortisol awakening response (CAR) and cortisol area under the curve with respect to ground (AUC-G).
Results: Caregivers with a "burned-out" or flattened CAR, and associated low AUC-G on non-ADS days displayed a more normative CAR and AUC-G response on ADS days. Restored cortisol regulation was also observed on ADS days among caregivers with the highest CAR and AUC-G levels on non-ADS days.
Implications: Results indicate that ADS use improves caregivers' cortisol regulation, which could enhance long-term health outcomes. Effects may be due to caregivers' anticipation of an easier day when the IWD attends ADS.

Key Words: Adult day services, Stress, Family caregivers, Cortisol

It is widely recognized that family caregivers of individuals with dementia (IWD) experience high levels of care-related stressors on a daily basis, are at increased risk of poor health outcomes, and have increased morbidity and mortality rates (Aneshensel, Pearlin, Mullan, Zarit, & Whitlatch, 1995; Capistrant, Moon, Berkman, & Glymour, 2012; Perkins et al., 2013). Interventions with caregivers have shown promising results in lowering subjective burden and depression (e.g., Belle et al., 2006; Hepburn, Tornatore, Center, & Ostwald, 2001). These interventions have mostly emphasized psychoeducational strategies that train caregivers to manage the IWD's behavior problems and other caregiving stressors more effectively. Another approach for helping caregivers is the use of respite services, including adult day services (ADS), in-home respite care, and overnight respite. In contrast to psychoeducational interventions, respite services have the advantage of reducing caregivers' exposure to care-related stressors by giving them time away from their relative. Prior research on ADS found that caregivers of IWD had a 43% reduction in exposure to behavior problems on days the IWD attended ADS compared with days they provided most or all of the care (Zarit et al., 2011). These effects were largely due to the time away that caregivers had from the IWD on ADS days, but behavior and sleep problems were also reduced in the time period immediately following ADS use (approximately 4:00 p.m. to the next morning). Reducing stressor exposure with ADS use also has both direct and buffering effects on caregivers' feelings of anger and depression (Zarit, Kim, Femia, Almeida, & Klein, in press).

The present study extends this research by exploring whether reducing stressor exposure through ADS use effects caregivers' biological responses to stress. The caregiving field has long relied almost exclusively on subjective reports. Although not without their limitations, biological stress markers are not prone to the same biases as subjective reports such as faulty recall and over- or underreporting of emotions. Furthermore, stressors increase risk of disease by diminishing biological resources, and biomarkers of the stress response offer a pathway for understanding this process (e.g., Epel, 2009; Miller, Chen, & Zhou, 2007). The hypothalamic-pituitary-adrenal (HPA) axis is a primary biological system for understanding the effects of daily and chronic life stressors on health (Kemeny, 2003). Cortisol, a product of the HPA axis, is a catabolic hormone that supports the fight-or-flight stress response. It has received considerable attention because of its sensitivity to psychosocial stress and as a predictor of general health and mortality (Kumari et al., 2011; Schoorlemmer, Peeters, van Schoor, & Lips, 2009; Wrosch et al., 2008). Cortisol has a normal diurnal pattern, reaching its peak within an hour of waking and then declining through the rest of the day. Acute stressors lead to increased cortical output in proximity to the experienced stressors as well as increases in the cortisol awakening response (CAR) and in total cortisol output on days when stressors occur (Stawski, Cichy, Piazza, & Almeida, 2013). Under conditions of chronic stress, however, the cortisol response is more variable, with evidence of both elevated and attenuated diurnal cortisol responses (Epel, 2009; Juster et al., 2011; Miller et al., 2007; Susman, 2006). These attenuated patterns have little or no morning rise and a flattened pattern of less decline over the rest of the day compared with normal patterns. Both of these response patterns increase risk of adverse physiological and health outcomes, including diminished immune system responsiveness (Chrousos, 1995) and hypertension (Wirtz et al., 2007), as well as neurotoxicity which may lead to cognitive decline and depression (Sapolsky, 2000). Other biomarkers also reveal pathways between stress and health outcomes, including indicators of immune functioning (e.g., reduced antibody titers to influenza vaccine) and cardiovascular disease (e.g., increased C-reactive protein; Kiecolt-Glaser, McGuire, Robles, & Glaser, 2002; von Känel et al., 2012).

Despite accumulating evidence of links between stressors and poor health outcomes, most field research on biomarkers in the general adult population and among caregivers has been correlational in nature. Thus, it is difficult to discern the causal sequence of stressful events and the underlying physiological mechanisms through which caregiving stressors may affect health. In contrast, daily diary design methods that use intensive repeated observations within individuals allow examination of within-person daily variation between stressors and health biomarkers (e.g., cortisol), which may offer insight into the role that caregiving stress plays in altering health.

Recent studies have examined the relation of daily stressors to diurnal cortisol responses in caregivers. Savla and colleagues (2013) followed a sample of spouses of persons with mild cognitive impairment over the course of 7 days and found that daily stressors were associated with elevated CAR and less cortisol decline during the day. Seltzer and colleagues studied daily stressors and their effects on diurnal cortisol patterns in mothers of adolescent or young adult offspring with developmental disabilities, including autism spectrum disorders and fragile X syndrome (Seltzer et al., 2010, 2012; Wong et al., 2012). Their work suggests that, similar to caregivers of an IWD, parent caregivers have elevated levels of self-reported daily stressors, negative affect, and physical symptoms compared with closely matched groups of unaffected parents. Furthermore, they found evidence of an attenuated CAR among mothers experiencing higher daily stress in conjunction with other contextual and risk factors. These findings support the conclusions of Miller and colleagues (2007) that cortisol may be elevated in response to stressors but may also assume a flattened daily pattern with chronic exposure to more severe and uncontrollable events.

Only a few studies have tested if interventions might lead to changes in biomarkers among caregivers. Moore and colleagues (2013) report that a six-session intervention that increases engagement in pleasant activities significantly improved a risk marker for cardiovascular disease, interleukin-6, as well as in depressive symptoms. Grant and colleagues (2003) likewise found that in-home respite use by caregivers led to reduced epinephrine and lower heart rate during a stressor task compared with a control group not receiving respite (Grant et al., 2003).

The current study provides a unique opportunity to examine causally whether ADS use provides opportunities for physiological recovery that potentially could improve long-term health and well-being of caregivers. Specifically, we examined whether ADS use altered daily salivary cortisol patterns in caregivers of IWD using a daily diary design that included eight consecutive days of daily saliva collection, across multiple times each day. Based on previous studies (Almeida, Piazza, & Stawski, 2009; Seltzer et al., 2010), we used two measures that capture daily variability of cortisol: CAR as measured by the increase in cortisol from waking to 30 min later, and total daily cortisol output as measured by area under the curve adjusted for ground (AUC-G) as primary outcomes of daily stressor exposure.

The 8-day span allowed for collection of saliva on days the IWD attended ADS and days when caregivers had primary care responsibility, thus providing a contrast between high and low exposure to care-related stressors. Earlier studies suggest that emotional and physical symptoms are worse on days when an individual reports more frequent stressors (Almeida, 2005), but no prior study has to our knowledge examined diurnal cortisol levels where daily stress exposure was manipulated by an intervention that alleviates caregiver stressor exposure. Consistent with the literature on the effects of chronic stressors on cortisol, we expected that some caregivers would demonstrate elevated CAR and AUC-G, and others would display a burned-out pattern of low or no CAR and low AUC-G on days they provided all the care for their relative. Furthermore, we expected that caregivers with elevated levels of cortisol output on non-ADS days would show reduced AUC-G on treatment days in response to lower stressors exposure when their relative attends ADS. By contrast, caregivers with low CAR and low daily output on non-ADS days were expected to display increased CAR and AUC-G on days their relative attends ADS.

Methods

Participants, Recruitment, and Procedure

Caregivers were referred from ADS programs in five regions of the country: Northern and Central New Jersey, the greater Philadelphia area, the greater Pittsburgh area, Northern Virginia, and Denver, Colorado. Eligibility criteria were that caregivers had to be related to and live with the IWD in a community setting, be that person's primary caregiver, be able to produce saliva and not have an endocrine disorder that could affect cortisol levels. We limited the sample to caregivers who lived with the IWD in order to assure that the intervention, ADS use, would lead to a difference in stressor exposure for caregivers on days the IWD attended ADS. The IWD had to have a physician's diagnosis of a dementing illness and attend ADS a minimum of 2 days a week or more.

Of a total of 241 referrals, we enrolled 200 (83%) caregivers who met study eligibility criteria (Figure 1). Main reasons for ineligibility were: not having a dementia diagnosis ($n = 16$), not living with the IWD ($n = 5$) and not using enough days of ADS ($n = 12$). Sixteen of the 200 eligible participants (8%), subsequently decided not to enroll in the study. Eleven participants (5.5%) were eliminated from the present analysis because they either did not complete daily interviews ($n = 2$) or the daily interviews did not include both ADS and non-ADS days ($n = 9$). Another nine participants were eliminated due to missing ($n = 8$) and invalid saliva samples ($n = 1$). Finally, six participants (3%) who did not have valid cortisol values on both ADS and non-ADS days were eliminated from the analyses. The resulting sample was 158 caregivers (79% of eligible participants) with valid and complete data. Characteristics of caregivers and IWDs who were included in the final sample ($n = 158$) and those who were not ($n = 26$) did not differ except on education and race of caregivers; the final sample had higher education level ($t = 2.21$, $p < .05$) and more white caregivers ($\chi^2 = 5.84$, $p < .05$). Table 1 presents characteristics of the final sample of caregivers and IWDs.

An initial interview in the caregiver's home obtained sociodemographic information and trained caregivers for the daily interviews and in saliva collection procedures. Participants received a saliva home collection kit (Starsdet, Cary, NC). They were instructed to provide five saliva samples per day (upon waking, 30 min after waking, before lunch, before dinner, and before bed) for eight consecutive days. Saliva was collected by rolling the cotton swab across the tongue for 2 min without chewing on the swab. The Penn State Survey Research Center called participants each of the eight evenings to assess daily stress experiences and well-being, and to address any problems participants encountered with saliva collection. Participants received $100 for completing the initial and daily interviews. Written informed consent was obtained for all participants, and all procedures in this study were approved by The Pennsylvania State University institutional review board.

Consistent with prior studies, participants recorded saliva collection times, medications taken within the past 48 hr, use of used tobacco products and for females, menstrual cycle information (Almeida, McGonagle, & King, 2009; Kirschbaum, Kudielka, Gaab, Schommer, & Hellhammer, 1999). Saliva collection times were confirmed during the daily calls. After the eighth day, participants shipped saliva samples via prepaid courier packages to our laboratory where they were frozen at −80 °C until assayed.

Main Outcome Measures

Salivary Cortisol Assessment

Salivary cortisol is a reliable measure of daily stress processes in social surveys of naturally occurring stressors that is correlated with serum measures (e.g., Almeida et al., 2009). Cortisol levels were assayed using commercially available enzyme immunoassay kits (EIA; Salimetrics, LLC, State College, PA). The sample test volume was 25 μl. The assay had a lower limit of sensitivity of 0.03 μg/dl, with an average inter- and intraassay covariance of less than 7% and 4%, respectively. All samples were tested in duplicate in a single assay batch. Duplicate test values that varied by more than 5% between well were subject to repeat testing. Values used in data analyses are the averages of duplicate tests. Cortisol data were converted to nmol/ml (μg/dl × 27.6). Table 2 presents cortisol values across the day.

Cortisol Awakening Response

Cortisol awakening response (CAR) was calculated for each day by subtracting the first salivary cortisol measure of the day (immediately upon waking) from the second measure (~30 min after waking) and then dividing the difference scores by the time interval between the two measures ([Cort B − Cort A]/[Time B − Time A]) (Fries, Dettenborn, & Kirschbaum, 2009).

Cortisol Area Under the Curve with respect to Ground

Total daily cortisol output was measured as AUC formed by the five daily measurements. We used the formula for area under

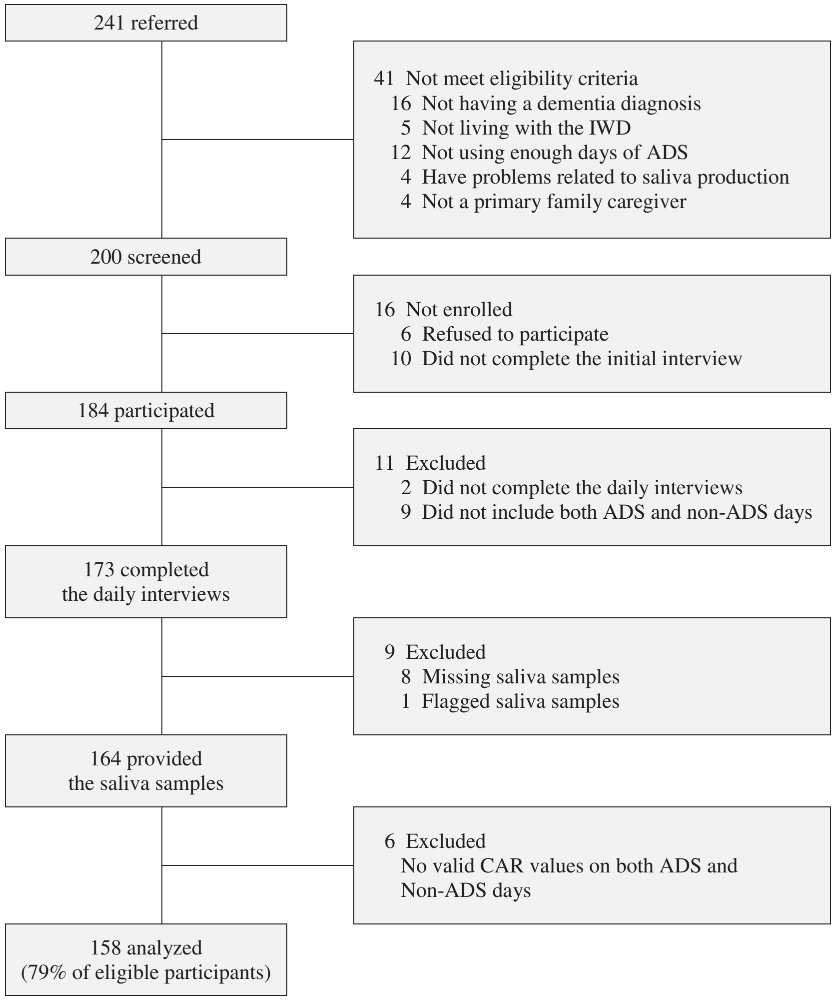

Figure 1. Participant selection flow chart.

the curve with respect to ground (AUC-G), which accounts for the variable time intervals between cortisol samples (Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003).

CAR and AUC-G Groupings

Initial review of patterns of cortisol response indicated considerable heterogeneity on non-ADS days that ranged from high levels of CAR and AUC-G and attenuated CAR and low AUC-G. To represent the variability in cortisol patterns, we divided participants into quartiles, based respectively on percentile scores of their CAR and AUC-G on non-ADS days (Table 3).

Type of Caregiving Day

Type of caregiving day, that is, whether the IWD used ADS (= 1) or did not use ADS (= 0), was confirmed during daily telephone interviews. Caregivers used an average of 4.15 (SD = 1.43) days of ADS during the 8 days.

Covariates

We included in our models three measures to determine the effects of ADS use on caregiver's daily exposure to stressors and positive events. These measures were obtained during the daily telephone interviews and provided a manipulation check that ADS lowered care-related stressors.

Daily care-related stressors were assessed with the Daily Record of Behavior, a 10-item scale which assesses daily frequency of Behavioral and Psychological Symptoms of Dementia (Femia, Zarit, Stephens, & Greene, 2007), including IWD's resistance to caregiver's help with daily activities, restless or agitated behaviors, disruptive behaviors, depressive behaviors, reality problems (e.g., hallucinations), and memory-related problems. Caregivers were asked about the occurrence of behavior problems during four time periods during the day: waking to 9:00 a.m., 9:00 a.m. to 4:00 p.m., 4:00 p.m. to bedtime, and overnight. The 9:00 a.m. to 4:00 p.m. period corresponded to the modal times that IWDs attended ADS. We summed the total number of problems that occurred during each day (α = .90).

Noncare stressors were assessed with the 8-item Daily Inventory of Stressful Events (DISE; Almeida, Wethington, & Kessler, 2002). Noncare stressors were events that caregivers found stressful, but were not directly related to the care they were providing to their relative. Events included arguments with other people, avoiding an argument, stressors affecting friends or family, health-related issues, financial issues, work-related events, or any other incidents. The number of events reported each day was summed for all daily events ($\alpha = .45$).

We also obtained a measure of daily positive events, using a 5-item scale from the DISE (Almeida et al., 2002). Items included: sharing a good laugh with someone, a positive experience at home, a positive experience with a close friend or relative, a positive experience at work, and any other positive experience. We summed the number of positive events that occurred each day ($\alpha = .58$).

Other covariates included caregivers' age, gender, duration of caregiving (months), and total number of days the IWD used ADS during the eight interview days. We considered the extent of IWD's disability using 13 items drawn from scales assessing personal and instrumental activities of daily living (ADL; Lawton & Brody, 1969). Caregivers reported the IWD's ability to perform each ADL activity, using a 4-point scale from 1 (*IWD was able to perform activity by him/herself without assistance*) to 4 (*IWD was totally dependent all the time on the activity*; $\alpha = .83$). Daily wake-up time was controlled in the models for its possible effects on cortisol.

Table 1. Characteristics of Caregivers and Individuals With Dementia

	M	*SD*	Range
Caregiver's characteristics			
Female, *n* (%)	138	(87.3)	—
Age	61.59	10.54	39–87
Spouse, *n* (%)	60	(38.0)	—
Child, *n* (%)	92	(58.2)	—
Education[a]	4.51	1.15	1–6
Income[b]	6.87	3.11	1–11
Duration of care (month)	62.05	46.00	3–264
White, *n* (%)	117	(74.1)	—
Married, *n* (%)	110	(69.6)	—
Employed, *n* (%)	68	(43.0)	—
Number of ADS days	4.15	1.43	1–6
IWD's characteristics			
Female, *n* (%)	95	(60.1)	—
Age	81.82	8.63	57–100
ADL impairment[c]	3.06	0.49	2–4

Notes: Participant $N = 158$. ADL = activities of daily living; ADS = adult day services; IWD = individual with dementia.
[a]Rated on a 6-point scale from 1 (*less than high school*) to 6 (*post-college degree*).
[b]Rated on a 11-point scale from 1 (*less than $10,000*) to 11 (*$100,000 or over*); due to missing, a different sample size was used ($n = 150$).
[c]Mean scores of 13 items rated on a 4-point scale ranged from 1 (*does not need help*) to 4 (*cannot do without help*).

Statistical Analyses

As an initial step in the analysis, we determined if the treatment, ADS use affected caregivers' daily experience, including exposure to stressors and positive events. Using two-level multilevel models (SAS PROC MIXED; Littell, Miliken, Stroup, & Wolfinger, 1996), we estimated levels of daily experiences for *d*th day in the *i*th person at level 1 (within-person):

$$\text{Experience}_{di} = \beta_{0i} + \beta_{1i}(\text{ADS use}_{di}) + e_{di}$$

We included ADS use (β_{1i}) to examine differences in daily levels of daily experiences by ADS use. At level 2 (between-person), we controlled five covariates for the intercept: caregiver's age, gender, duration of care, IWD's ADL impairment, and number of ADS days.

Next, we examined the effects of ADS use on daily salivary cortisol levels and if these effects differed by quartile groups, employing multilevel models which allow us to estimate variability in cortisol levels across days and across participants (Almeida et al., 2009). We estimated separate models for CAR and AUC-G. At level 1, we modeled cortisol

Table 2. Saliva Collection Times and Cortisol Levels of Caregivers

	Day	Collection time (decimal hours)		Cortisol level (nmol/L)		
	n	*M*	*SD*	*M*	*SD*	ICC
Individual samples						
Sample A (waking)	1,207	6.75	1.28	9.12	5.89	.37
Sample B (30 min after waking)	1,153	7.31	1.29	12.28	6.95	.38
Sample C (before lunch)	1,165	12.82	1.23	4.02	2.96	.31
Sample D (around 5:00 p.m.)	1,213	17.45	1.18	2.99	3.84	.27
Sample E (before bed)	1,173	22.68	1.21	2.72	4.69	.21
Composite indicators						
CAR	1,128	—	—	5.79	12.25	.21
AUC-G[a]	960	—	—	78.55	37.80	.41

Notes: Participant $N = 158$. AUC-G = area under the curve with respect to ground; CAR = cortisol awakening response; ICC = intraclass correlation.
[a]Due to the criteria for flagged saliva samples, AUC-G has a different sample size ($n = 147$).

Table 3. Quartile Groups of Cortisol Levels on Non-ADS Days

	CAR			AUC-G		
	n	*M*	*SD*	*n*	*M*	*SD*
Total sample	158	3.99	8.49	147	74.55	30.99
Quartile groups						
Low (1st quartile)	39	−5.77	5.99	37	43.59	7.88
Medium (2nd quartile)	40	1.45	1.43	37	61.79	4.49
Medium–high (3rd quartile)	40	5.57	1.52	37	77.43	4.72
High (4th quartile)	39	14.76	5.55	36	116.54	29.87

Notes: ADS = adult day services; AUC-G = area under the curve with respect to ground; CAR = cortisol awakening response.

scores (i.e., CAR and AUC-G) for *d*th day in the *i*th person, including five within-person (day-to-day) variables: ADS use was a main predictor and daily wake-up time and three daily experiences of caregivers (i.e., care-related stressors, noncare stressors, and positive events) were control variables. The daily measures were centered at the individual mean to represent within-person effects (Hoffman & Stawski, 2009).

$$\begin{aligned}\text{Cortisol}_{di} = {} & \beta_{0i} + \beta_{1i}(\text{ADS}_{di}) \\ & + \beta_{2i}(\text{Wake-up time}_{di} - i\text{Mean\_Wake-up time}_i) \\ & + \beta_{3i}(\text{Care-related stressor}_{di} - i\text{Mean\_Care-related stressor}_i) \\ & + \beta_{4i}(\text{Noncare stressor}_{di} - i\text{Mean\_Noncare stressor}_i) \\ & + \beta_{5i}(\text{Positive event}_{di} - i\text{Mean\_Positive event}_i) + e_{di}\end{aligned}$$

At level 2, the level 1 intercept (β_{0i}) and slope parameters (β_{1i}, β_{2i}, β_{3i}, β_{4i}, and β_{5i}) were treated as outcomes. Quartile groups of non-ADS day cortisol scores were included as between-person predictors for the intercept (γ_{01}, γ_{02}, and γ_{03}) and ADS slope (γ_{11}, γ_{12}, and γ_{13}). In these models, we used the highest quartile group as the reference group. We also included nine covariates for the intercept: caregiver's age and gender, duration of care, ADL impairment of IWD, number of ADS days, and the person-mean levels of wake-up time and three daily experiences (i.e., care-related stressors, noncare stressors, and positive events).

$$\begin{aligned}\beta_{0i} = {} & \gamma_{00} + \gamma_{01}(\text{Low}_i) + \gamma_{02}(\text{Medium}_i) + \gamma_{03}(\text{Medium–High}_i) \\ & + \gamma_{04}(\text{CG Age}_i) + \gamma_{05}(\text{CG Female}_i) + \gamma_{06}(\text{Duration of care}_i) \\ & + \gamma_{07}(\text{IWD ADL impairment}_i) + \gamma_{08}(\text{Number of ADS days}_i) \\ & + \gamma_{09}(i\text{Mean\_Wake-up time}_i) + \gamma_{10}(i\text{Mean\_Care-related stressor}_i) \\ & + \gamma_{11}(i\text{Mean\_Noncare stressor}_i) + \gamma_{12}(i\text{Mean\_Positive event}_i) + u_{0i} \\ \beta_{1i} = {} & \gamma_{10} + \gamma_{11}(\text{Low}_i) + \gamma_{12}(\text{Medium}_i) + \gamma_{13}(\text{Medium–High}_i) \\ \beta_{2i} = {} & \gamma_{20} \\ \beta_{3i} = {} & \gamma_{30} \\ \beta_{4i} = {} & \gamma_{40} \\ \beta_{5i} = {} & \gamma_{50}\end{aligned}$$

Cohen's *d* was used to estimate effect sizes of findings.

Results

ADS Use and Daily Experiences

An initial multilevel model (Table 4) showed that ADS use had significant effects on each of the three daily experiences (Table 4). Caregivers had lower care-related stressors (d = 0.21), more positive experiences (d = 0.09), but also had more noncare stressors (d = 0.08) on days their relative attended ADS compared with days when they provided most or all of the care.

Cortisol Awakening Response

Multilevel models show the effects of ADS on CAR using the high CAR group as the reference group (Table 5). We focused on within-person effects. We found significant two-way interaction effects between ADS use and CAR quartile group (d = 0.19). Thus, the effect of ADS was conditioned by the level of CAR on non-ADS days. As Figure 2 describes, the low quartile who displayed a negative awakening response on non-ADS days showed a positive CAR on ADS days. The medium quartile with a flat CAR on non-ADS days showed an increased CAR on ADS days. The medium–high quartile also displayed an increased CAR on ADS days but the high group displayed a decreased CAR on ADS days compared with non-ADS days. No other variables had significant effects on CAR.

Cortisol AUC-G

Multilevel models were repeated for cortisol AUC-G (Table 5). Again, we focus on the within-person effects. The AUC-G model revealed three significant interactions with ADS use and quartile grouping. Specifically, the effects of ADS use on AUC-G differed depending on AUC-G patterns on non-ADS days (d = 0.14). Compared with the high group, the low, medium, and high–medium quartiles displayed higher AUC-G on ADS days. Total number of ADS days during the 8-day period was associated with significantly higher between-person AUC-G. Caregiver's age was positively associated with the levels of AUC-G and daily wake-up time showed a negative effect on the AUC-G levels, that is, later wake-up time was associated with lower daily AUC-G.

Discussion

We examined whether ADS use altered daily salivary cortisol patterns in caregivers of IWD using a daily diary design that included 8 days of daily saliva collection, across multiple times within each day. We found that responses depended on diurnal cortisol patterns on non-ADS days. Specifically, caregivers with a "burned-out" or flattened CAR, and associated low AUC-G on non-ADS

Table 4. Daily Experiences of Family Caregivers by ADS Use

	ADS days		Non-ADS days		ADS effect[a]		
	M	*SD*	*M*	*SD*	*B*	*SE*	*p* value
Care-related stressors	3.88	5.59	4.88	6.11	−1.25	0.18	<.001
Noncare stressors	1.21	1.25	1.02	1.24	0.17	0.06	.006
Positive events	2.57	1.33	2.31	1.36	0.19	0.06	.003

Notes: Participant N = 158; Observation N = 1,128. ADL = activities of daily living; ADS = adult day services; CG = caregiver; IWD = individual with dementia.
[a]Fixed effects of ADS use (*ADS day* = 1, *non-ADS day* = 0) showed differences between ADS day and non-ADS day in multilevel models; p values are based on t values of coefficients for ADS use (df = 969); CG's age, gender, and duration of care, IWD's ADL impairment, and number of ADS days were included as (between-person) control variables.

days appeared to recover on ADS days, displaying a more normative CAR and AUC-G response. Prior reports have identified attenuated cortisol responses among people experiencing high levels of chronic stress (Miller et al., 2007; Susman, 2006), including caregivers (Seltzer et al., 2010, 2012), but this is the first time to our knowledge that a caregiver intervention has been associated with improvement in cortisol. In addition, caregivers with the highest CAR and AUC-G levels on non-ADS days displayed a lower and more normative CAR and AUC-G on ADS days. Together, these results suggest that relief from caregiver stressors through respite care (ADS use) may restore or improve HPA axis regulation, as measured by daily cortisol. Although the benefits of ADS on cortisol regulation may not generalize to days when caregivers provide most or all of the care themselves, the more days that caregivers use ADS, the more relief they will show in diurnal cortisol levels.

Table 5. Effects of ADS Use on Cortisol CAR and AUC-G of Caregivers

	CAR			AUC-G		
	B	*SE*	*p* value	*B*	*SE*	*p* value
Fixed effects						
Intercept	15.12	1.42	<.000	119.80	4.70	<.000
Within-person predictors						
ADS	−1.84	1.35	.18	−14.61	4.01	<.000
ADS × Low group[a]	10.15	1.86	<.000	24.64	5.50	<.000
ADS × Medium group[a]	4.86	1.83	.008	19.23	5.35	<.000
ADS × Medium–High group[a]	3.36	1.82	.07	21.06	5.37	<.000
Wake-up time	−0.62	0.46	.18	−7.88	1.35	<.000
Care-related stressors	−0.05	0.12	.69	−0.38	0.33	.26
Noncare stressors	−0.09	0.36	.80	0.58	1.02	.57
Positive events	−0.61	0.34	.08	−1.30	1.01	.20
Between-person predictors						
Low group[a]	−20.08	1.46	<.000	−71.52	4.70	<.000
Medium group[a]	−12.70	1.40	<.000	−52.59	4.54	<.000
Medium–High group[a]	−9.01	1.37	<.000	−37.51	4.41	<.000
CG age	−0.00	0.04	.90	0.32	0.13	.014
CG female (yes = 1)	−0.44	1.11	.69	−1.11	4.02	.78
Duration of care (month)	−0.00	0.01	.90	−0.05	0.03	.09
IWD ADL impairment	0.72	0.78	.35	5.43	2.84	.06
Number of ADS days	0.07	0.28	.80	2.33	0.98	.019
Wake-up time	−0.43	0.37	.25	0.01	1.32	.99
Care-related stressors	−0.03	0.07	.73	−0.25	0.25	.31
Noncare stressors	0.12	0.46	.79	0.11	1.65	.95
Positive events	0.25	0.40	.53	−0.01	1.40	.99
Random effects						
Intercept VAR	3.85	2.31	.048	94.54	27.83	<.000
Residual VAR	112.69	5.11	<.000	799.45	39.98	<.000
−2 Log likelihood		8,564.9			9,224.2	

Notes: Participant N = 158; Observation N = 1,128 for CAR. Participant N = 147; Observation N = 960 for AUC-G. For fixed effects in the multilevel models, p values are based on t values of coefficients (df = 962 for CAR within-person predictors; df = 805 for AUC within-person predictors). ADL = activities of daily living; ADS = adult day services; CAR = cortisol awakening response; CG = caregiver; AUC-G = area under the curve with respect to ground; IWD = individual with dementia; VAR = variance.
[a]Reference = High group.

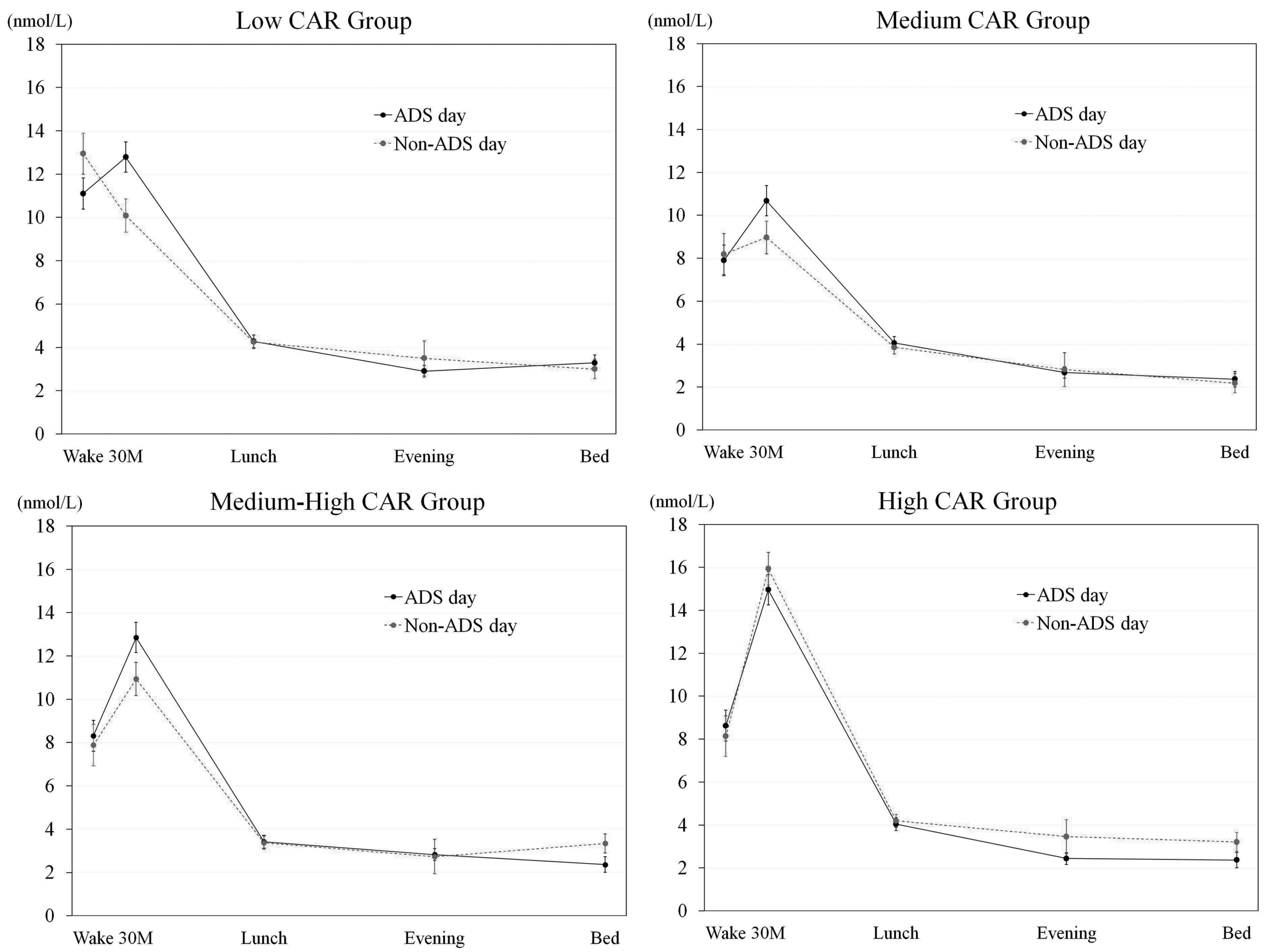

Figure 2. Effects of adult day service (ADS) use on cortisol awakening response (CAR) by quartile groups (means ± standard error of the mean).

We anticipated that ADS would affect cortisol by lowering stressor exposure, and we confirmed that care-related stressors were lower on ADS days, although noncare stressors rose slightly on days caregivers used ADS. We also expected that most of the effects on ADS days would occur after the morning waking period when caregivers were no longer providing care, but there were instead robust effects on morning rise before the IWD leaves for ADS. Caregivers may look forward to ADS days and begin the days with a greater focus on getting through their morning routine. We have not found other studies where anticipation of receiving assistance has this type of effect among caregivers. Previous research, however, found that caregivers looked forward to the time that the IWD attends ADS, and that they had time to relax and do things for themselves (Jarrott, Zarit, Stephens, Townsend, & Greene, 1999). We found similar results in the present study; 85.4% of caregivers reported they completely agreed with the statement that they look forward to their relative attending ADS. We also did not find an increase in stressors for caregivers in the morning period on days the IWD attended ADS compared with days the IWD remained at home with caregivers, either in the current study (Zarit et al., in press) or prior work (Zarit et al., 2011).

We recently reported that ADS use directly improved daily affect in a larger group of these caregivers and that ADS use was associated with temporary relief from daily caregiver burdens (Zarit et al., in press). One path through which caregiving erodes general health and well-being is through chronic exposure to daily stressors (Epel, 2009; Piazza, Charles, Sliwinski, Mogle, & Almeida, 2013). Both persistent levels of diurnal cortisol activation and attenuation are associated with increased risk of illness, as well as with depression and other mental health problems (Miller et al., 2007; Piazza et al., 2010). The current findings suggest that ADS use may ameliorate the cumulative physiological effects of chronic stressor exposure by providing an opportunity for physiological recovery which ultimately can reduce allostatic load and improve health outcomes. These findings confirm the long-held belief that caregivers benefit from getting breaks from care. At least a portion of this benefit, however, is from anticipation of time away, as well as relief from stressors.

It is important to note the limitations of this study. There may be a selection bias in the study population. Individuals who were willing to participate in 8 days of interviews and saliva collection may differ in important ways from other caregivers. Although the proportion of eligible participants eliminated from the sample was relatively small (21%), especially considering the high demands of the study, the final sample was not as representative as the full sample in terms of race and education. Further, we limited our sample to caregivers living with the IWD, which means that our findings may not generalize to caregivers who do not reside with their IWD. We did also not test for regional differences because of small numbers in some regions. Finally, although cortisol has been found to raise susceptibility to physical and mental health problems, there are no clinical norms for risk. Furthermore, focus on a single biomarker necessarily limits our understanding of biological responses to stress.

The findings suggest that ADS is a potentially important intervention that could result in long-term health benefits. Family caregivers to IWDs often provide many years of intensive care and have increased rates of mental and physical health problems as a result (Aneshensel et al., 1995; Lovell & Wetherell, 2011; von Känel et al., 2012). Interventions such as ADS that provide partial relief from daily stressors may help caregivers provide care longer while reducing their risk of illness. From a clinical perspective, screening of cortisol patterns among caregivers will identify people particularly in need of ADS or a similar respite intervention to reduce the health risks associated with dysregulated daily cortisol. Further studies are needed to evaluate the ADS exposure effects (i.e., number of ADS days) and additional health outcome measures in order to fully realize the broad benefits of respite care on the long-term health and well-being of caregivers.

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References

Almeida, D. M. (2005). Resilience and vulnerability to daily stressors assessed via diary methods. *Current Directions of Psychological Science*, *14*, 64–68. doi:10.1111/j.0963-7214.2005.00336.x

Almeida, D. M., McGonagle, K., & King, H. (2009). Assessing daily stress processes in social surveys by combining stressor exposure and salivary cortisol. *Biodemography and Social Biology*, *55*, 219–237. doi:10.1080/19485560903382338

Almeida, D. M., Piazza, J. R., & Stawski, R. S. (2009). Interindividual differences and intraindividual variability in the cortisol awakening response: An examination of age and gender. *Psychology and Aging*, 24, 819–827. doi:10.1037/a0017910

Almeida, D. M., Wethington, E., & Kessler, R. C. (2002). The daily inventory of stressful events: An interview-based approach for measuring daily stressors. *Assessment*, *9*, 41–55. doi:10.1177/1073191102091006

Aneshensel, C. S., Pearlin, L. I., Mullan, J. T., Zarit, S. H., & Whitlatch, C. J. (1995). *Profiles in caregiving: The unexpected career*. New York: Academic Press.

Belle, S. H., Burgio, L., Burns, R., Coons, D., Czaja, S. J., Gallagher-Thompson, D., … Resources for Enhancing Alzheimer's Caregiver Health (REACH) II Investigators (2006). Enhancing the quality of life of dementia caregivers from different ethnic or racial groups. *Annals of Internal Medicine*, *145*, 727–738. doi:10.7326/0003-4819-145-10-200611210-00005

Capistrant, B. D., Moon, J. R., Berkman, L. F., & Glymour, M. M. (2012). Current and long-term spousal caregiving and onset of cardiovascular disease. *Journal of Epidemiology and Community Health*, *66*, 951–956. doi:10.1136/jech-2011–200040

Chrousos, G. P. (1995). The hypothalamic-pituitary-adrenal axis and immune-mediated inflammation. *The New England Journal of Medicine*, *332*, 1351–1362. doi:10.1056/NEJM199505183322008

Epel, E. S. (2009). Psychological and metabolic stress: A recipe for accelerated cellular aging? *Hormones (Athens, Greece)*, *8*, 7–22. doi:10.14310/horm.2002.1217

Femia, E. E., Zarit, S. H., Stephens, M. A., & Greene, R. (2007). Impact of adult day services on behavioral and psychological symptoms of dementia. *The Gerontologist*, *47*, 775–788. doi:10.1093/geront/47.6.775

Fries, E., Dettenborn, L., & Kirschbaum, C. (2009). The cortisol awakening response (CAR): Facts and future directions. *International Journal of Psychophysiology: Official Journal of the International Organization of Psychophysiology*, *72*, 67–73. doi:10.1016/j.ijpsycho.2008.03.014

Grant, I., McKibbin, C. L., Taylor, M. J., Mills, P., Dimsdale, J., Ziegler, M., & Patterson, T. L. (2003). In-home respite intervention reduces plasma epinephrine in stressed Alzheimer caregivers. *The American Journal of Geriatric Psychiatry: Official Journal of the American Association for Geriatric Psychiatry*, *11*, 62–72. doi:10.1097/00019442-200301000-00009

Hepburn, K. W., Tornatore, J., Center, B., & Ostwald, S. W. (2001). Dementia family caregiver training: Affecting beliefs about caregiving and caregiver outcomes. *Journal of the American Geriatrics Society*, *49*, 450–457. doi:10.1046/j.1532-5415.2001.49090.x

Hoffman, L., & Stawski, R. S. (2009). Person as contexts: Valuating between-person and within-person effects in longitudinal analysis. *Research and Human Development*, *6*, 97–120. doi:10.1080/15427600902911189

Jarrott, S. E., Zarit, S. H., Stephens, M. A. P., Townsend, A., & Greene, R. (1999). Caregiver satisfaction with adult day service programs. *American Journal of Alzheimer's Disease*, *14*, 233–244. doi:10.1177/153331759901400403

Juster, R. P., Sindi, S., Marin, M. F., Perna, A., Hashemi, A., Pruessner, J. C., & Lupien, S. J. (2011). A clinical allostatic load index is associated with burnout symptoms and hypocortisolemic profiles in healthy workers. *Psychoneuroendocrinology*, *36*, 797–805. doi:10.1016/j.psyneuen.2010.11.001

Kemeny, M. E. (2003). The psychobiology of stress. *Current Directions in Psychological Science*, *12*, 124–129. doi:10.1111/1467–8721.01246

Kiecolt-Glaser, J. K., McGuire, L., Robles, T. F., & Glaser, R. (2002). Psychoneuroimmunology: Psychological influences on immune function and health. *Journal of Consulting Clinical Psychology*, *7*, 537–547. doi:10.1037//0022-006X.70.3.537

Kirschbaum, C., Kudielka, B. M., Gaab, J., Schommer, N. C., & Hellhammer, D. H. (1999). Impact of gender, menstrual cycle phase, and oral contraceptives on the activity of the hypothalamus-pituitary-adrenal axis. *Psychosomatic Medicine*, *61*, 154–162. doi: 10.1097/00006842-199903000-00006

Kumari, V., Fannon, D., Peters, E. R., ffytche, D. H., Sumich, A. L., Premkumar, P., … Kuipers, E. (2011). Neural changes following cognitive behaviour therapy for psychosis: A longitudinal study. *Brain: A Journal of Neurology*, *134*, 2396–2407. doi:10.1093/brain/awr154

Lawton, M. P., & Brody, E. M. (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *The Gerontologist*, *9*, 179–186. doi:10.1093/geront/9.3_Part_1.179

Littell, R. C., Miliken, G. A., Stroup, W. W., & Wolfinger, R.D. (1996). *SAS systems for mixed models*. Cary, NC: SAS Institute.

Lovell, B., & Wetherell, M. A. (2011). The cost of caregiving: Endocrine and immune implications in elderly and non elderly caregivers. *Neuroscience and Biobehavioral Reviews*, *35*, 1342–1352. doi:10.1016/j.neubiorev.2011.02.007

Miller, G. E., Chen, E., & Zhou, E. S. (2007). If it goes up, must it come down? Chronic stress and the hypothalamic-pituitary-adrenocortical axis in humans. *Psychological Bulletin*, *133*, 25–45. doi:10.1037/0033-2909.133.1.25

Moore, R. C., Chattillion, E. A., Ceglowski, J., Ho, J., von Känel, R., Mills, P. J., … Mausbach, B. T. (2013). A randomized clinical trial of Behavioral Activation (BA) therapy for improving psychological and physical health in dementia caregivers: Results of the Pleasant Events Program (PEP). *Behaviour Research and Therapy*, *51*, 623–632. doi:10.1016/j.brat.2013.07.005

Perkins, M., Howard, V. J., Wadley, V. G., Crowe, M., Safford, M. M., Haley, W. E., … Roth, D. L. (2013). Caregiving strain and all-cause mortality: Evidence from the REGARDS study. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, *68*, 504–512. doi:10.1093/geronb/gbs084

Piazza, J. R., Almeida, D. M., Dmitrieva, N. O., & Klein, L. C. (2010). Frontiers in the use of biomarkers of health in research on stress and aging. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *65*, 513–525. doi:10.1093/geronb/gbq049

Piazza, J. R., Charles, S. T., Sliwinski, M. J., Mogle, J., & Almeida, D. M. (2013). Affective reactivity to daily stressors and long-term risk of reporting a chronic physical health condition. *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine*, *45*, 110–120. doi:10.1007/s12160-012-9423-0

Pruessner, J. C., Kirschbaum, C., Meinlschmid, G., & Hellhammer, D. H. (2003). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology*, *28*, 916–931. doi:10.1016/S0306-4530(02)00108-7

Sapolsky, R. M. (2000). The possibility of neurotoxicity in the hippocampus in major depression: A primer on neuron death. *Biological Psychiatry*, *48*, 755–765. doi:10.1016/S0006-3223(00)00971-9

Savla, J., Granger, D. A., Roberto, K. A., Davey, A., Blieszner, R., & Gwazdauskas, F. (2013). Cortisol, alpha amylase, and daily stressors in spouses of persons with mild cognitive impairment. *Psychology and Aging*, *28*, 666–679. doi:10.1037/a0032654

Schoorlemmer, R. M., Peeters, G. M., van Schoor, N. M., & Lips, P. (2009). Relationships between cortisol level, mortality and chronic diseases in older persons. *Clinical Endocrinology*, *71*, 779–786. doi:10.1111/j.1365-2265.2009.03552.x

Seltzer, M. M., Greenberg, J. S., Hong, J., Smith, L. E., Almeida, D. M., Coe, C., & Stawski, R. S. (2010). Maternal cortisol levels and behavior problems in adolescents and adults with ASD. *Journal of Autism and Developmental Disorders*, *40*, 457–469. doi:10.1007/s10803-009-0887-0

Seltzer, M. M., Barker, E. T., Greenberg, J. S., Hong, J., Coe, C., & Almeida, D. (2012). Differential sensitivity to life stress in FMR1 premutation carrier mothers of children with Fragile X Syndrome. *Health Psychology*, *5*, 612–622. doi:10.1037/a0026528

Stawski, R. S., Cichy, K. E., Piazza, J. R., & Almeida, D. M. (2013). Associations among daily stressors and salivary cortisol: Findings from the National Study of Daily Experiences. *Psychoneuroendocrinology*, *11*, 2854–2865. doi:10.1016/j.psyneuen.2013.06.023

Susman, E. J. (2006). Psychobiology of persistent antisocial behavior: Stress, early vulnerabilities and the attenuation hypothesis. *Neuroscience and Biobehavioral Reviews*, *30*, 376–389. doi:10.1016/j.neubiorev.2005.08.002

von Känel, R., Mills, P. J., Mausbach, B. T., Dimsdale, J. E., Patterson, T. L., Ziegler, M. G., … Grant, I. (2012). Effect of Alzheimer caregiving on circulating levels of C-reactive protein and other biomarkers relevant to cardiovascular disease risk: A longitudinal study. *Gerontology*, *58*, 354–365. doi:10.1159/000334219

Wirtz, P. H., von Känel, R., Emini, L., Ruedisueli, K., Groessbauer, S., Maercker, A., & Ehlert, U. (2007). Evidence for altered hypothalamus-pituitary-adrenal axis functioning in systemic hypertension: Blunted cortisol response to awakening and lower negative feedback sensitivity. *Psychoneuroendocrinology*, *32*, 430–436. doi:10.1016/j.psyneuen.2007.02.006

Wong, J. D., Seltzer, M. M., Greenberg, J. S., Hong, J., Almeida, D. M., & Coe, C. L. (2012). Stressful life events and daily stressors affect awakening cortisol level in midlife mothers of individuals with autism spectrum disorders. *Aging and Mental Health*, *16*, 939–949. doi:10.1080/13607863.2012.688191

Wrosch, C., Miller, G. E., Lupien, S., & Pruessner, J. C. (2008). Diurnal cortisol secretion and 2-year changes in older adults' physical symptoms: The moderating roles of negative affect and sleep. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association*, *27*, 685–693. doi:10.1037/0278-6133.27.6.685

Zarit, S. H., Kim, K., Femia, E. E., Almeida, D. M., Savla, J., & Molenaar, P. C. M. (2011). Effects of adult day care on daily stress of caregivers: A within-person approach. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, *66B*, 538–546. doi:10.1093/geronb/gbr030

Zarit, S. H., Kim, K., Femia, E. E., Almeida, D. M., & Klein, L. C. The effects of adult day services on family caregivers' daily stress, affect and health: Outcomes from the Daily Stress and Health (DaSH) Study. *The Gerontologist*, in press. doi:10.1093/geront/gnt045